SOIL SURVEY OF

Crawford County, Iowa

Major fieldwork for this soil survey was done in the period 1959–63. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agricultural and Home Economics Experiment Station. It is part of the technical assistance furnished to the Crawford County Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Crawford County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife and Recreation."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Crawford County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning of the publication and in the section "General Nature of the County."

Cover picture: Farm ponds and terraces in the Marshall association.

U.S. GOVERNMENT PRINTING OFFICE: 1973

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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SOIL SURVEY OF CRAWFORD COUNTY, IOWA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURAL AND HOME ECONOMICS EXPERIMENT STATION

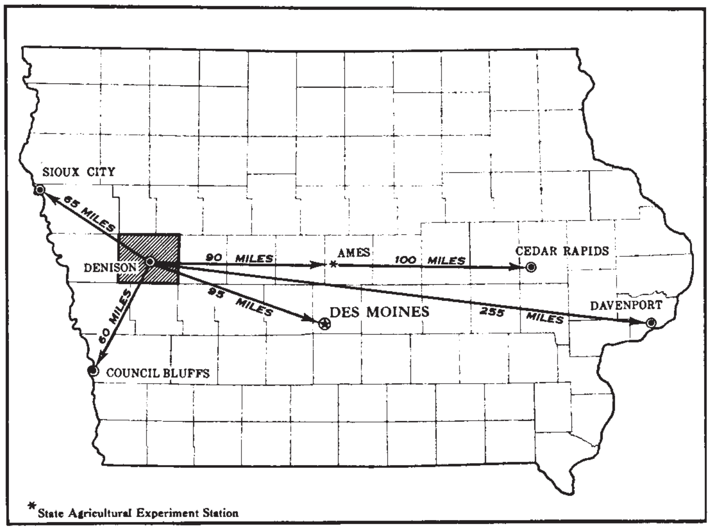


Figure 1.—**Location of Crawford County in Iowa.**

CRAWFORD COUNTY is in the western part of Iowa (fig. 1). It has an area of about 458,240 acres. Denison is the county seat and largest town in the county.

Crawford County is mainly agricultural, and most of the acreage is in farms. The principal crops are corn, soybeans, oats, hay, and pasture plants, but most of the cropland is in corn. The production of livestock far exceeds other kinds of farming and consists mainly of or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey (*23*).[1]

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Colo and Marshall, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Colo silt loam, overwash, is one of two phases within the Colo series.

After a guide for classifying and naming the soils some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such mapping unit shown on the soil map of Crawford County is the soil complex.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Judson-Colo-Nodaway complex, 2 to 6 percent slopes.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that is readily useful to different groups of readers, among them farmers and engineers.

The soil scientists set up trial groups on the basis of yield and practice tables and other data. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and depth, stoniness, drainage, and other characteristics that affect their management.

The four soil associations in Crawford County are described in the following pages.

1. Monona-Ida association

Nearly level to steep, well-drained silty soils on uplands

This association (fig. 2) consists of nearly level to steep soils on a series of rounded ridges that have smooth, convex side slopes leading to the drainageways. It is in the rolling, hilly area of the county, mainly in the western half (fig. 3). Slopes mostly range from 9 to 25 percent, but some slopes range up to 40 percent in the most dissected parts of the association. These are mainly where drainageways and smaller streams are descending to larger streams, such as the Boyer River.

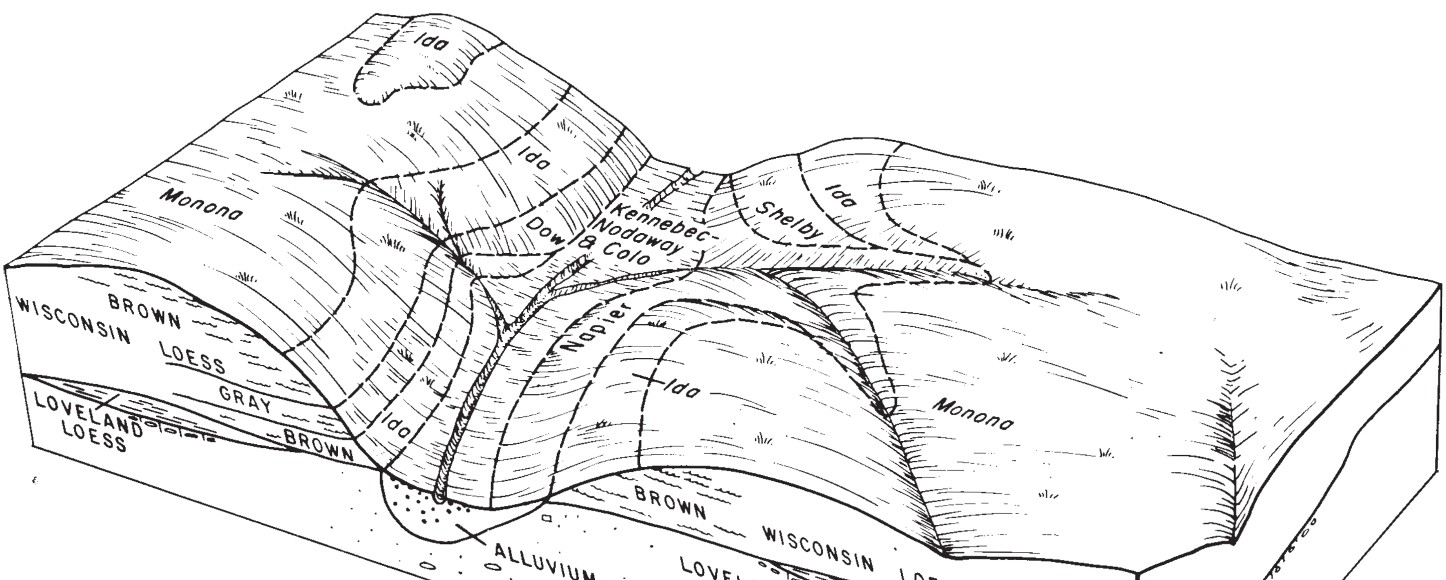
This association makes up about 43 percent of the county. Monona soils make up about 60 percent of the association; Ida soils, about 12 percent; and minor soils, the remaining 28 percent. Monona and Ida soils formed in thick loess under prairie vegetation.

Monona soils are on the broader ridges and long, smooth side slopes. The largest areas of these soils are moderately or strongly sloping. Monona soils have a surface layer of very dark brown and very dark grayish-brown silt loam. Beneath is dark-brown to dark yellowish-brown, moderately permeable silt loam. These soils are typically slightly acid in the surface layer and slightly acid or neutral in the subsoil.

Ida soils are on narrow, undulating ridgetops and side slopes. Slopes range from moderate to steep. Ida soils have a surface layer of dark-brown to brown silt loam. Beneath is very friable, yellowish-brown silt loam. These soils are calcareous at or near the surface, and lime concretions are throughout.

Monona and Ida soils are easy to till and respond well to good management.

Figure 2.—**A typical landscape in the Monona-Ida association.**



2. Marshall association

mixtures, and red clover, are also grown. A few areas, mainly along streams, are used for permanent pasture.

and the Monona-Ida soil associations. Monona soils make up about 39 percent of the association; Marshall soils, about 15 percent; and minor soils, the remaining 46 percent. Monona and Marshall soils formed in thick

stabilized so that the channels do not migrate within the flood plains.

This association makes up about 8 percent of the county. Kennebec soils make up about 35 percent of the association; Nodaway soils, about 24 percent; Colo soils, used in describing soil series and mapping units are

moderate medium subangular blocky structure break-

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent	Soil	Acres	Percent
Adair soils, 9 to 14 percent slopes, severely eroded	302	0. 1	Monona silt loam, 5 to 9 percent slopes, moderately eroded	30, 266	6. 6
Adair soils, 14 to 18 percent slopes, severely eroded	388	. 1	Monona silt loam, 5 to 9 percent slopes, severely eroded	2, 127	. 5
Chute fine sandy loam, 6 to 12 percent slopes, severely eroded	202	(1)	Monona silt loam, 9 to 14 percent slopes	1, 792	. 4
			Monona silt loam, 9 to 14 percent slopes, mod-		

Adair soils, 14 to 18 percent slopes, severely eroded (AdE3).—These soils have a surface layer that is dark brown to dark grayish brown or dark yellowish brown and 3 to 7 inches thick in most places. In some areas the surface layer is very dark grayish brown. The texture is dominantly clay loam but is clay or silty clay loam

C—9 to 72 inches, light yellowish-brown (10YR 6/4) to brownish-yellow (10YR 6/6) fine sand; single grain; very friable; moderately alkaline; calcareous.

The surface layer ranges from 3 to 10 inches in thickness. It is typically very dark grayish brown, dark grayish brown, dark brown, or brown, but in places it is dark yellowish brown to light yellowish brown. The darker colored surface protected from flooding. Most areas are not flooded frequently enough to prevent cultivation.

Representative profile of nearly level Colo silty clay loam, 300 feet east of the northwest corner of SW¼ sec. 1, T. 84 N., R. 37 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; weak and moderate, fine and medium, subangular blocky and fine, granular structure; friable; many fine roots; slightly acid; clear, smooth boundary.

A11—6 to 14 inches, black (10YR 2/1) silty clay loam; weak and moderate, fine and medium, subangular blocky structure; friable; many fine roots; neutral; gradual, smooth boundary.

A12—14 to 26 inches, black (10YR 2/1) silty clay loam; moderate, medium, subangular blocky structure breaking to fine subangular blocky; friable; neutral; gradual, smooth boundary.

A13—26 to 37 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure breaking to fine subangular blocky; firm; neutral; diffuse, smooth boundary.

B2—37 to 48 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure breaking to fine subangular blocky; firm; neutral; diffuse, smooth boundary.

B3g—48 to 60 inches +, very dark gray (N 3/0) silty clay loam; weak, medium, subangular blocky structure breaking to massive; firm; mildly alkaline.

Colo soils are black or very dark gray in the upper 36 inches unless recent overwash is present. Overwashed Colo soils have a layer on the surface that is very dark grayish-brown or dark grayish-brown silt loam 6 to 15 inches thick. The surface layer is 24 to 40 inches thick in most places. The underlying subsoil or substratum ranges from black to dark gray. The depth described in the representative profile does not extend to the substratum.

Texture throughout the profile is light to medium silty clay loam. The surface layer is generally slightly acid or neutral, but in places the upper 1 foot of the profile is medium acid.

Colo soils are finer textured throughout, more poorly drained, and less friable than Kennebec soils. They lack the stratification of the Nodaway soils and are darker colored, more poorly drained, and finer textured throughout. Colo soils are similar to Zook soils to a depth of about 12 inches but are not so fine textured below that depth. These soils are associated on the landscape, and all formed in alluvium.

Colo silt loam, overwash (0 to 2 percent slopes) (Co).—This soil has a profile similar to that described as representative for the series, except that it has recent deposits of sediment that consists of very dark grayish-

or Kennebec soils, which are along the streams. It is also associated with Zook soils. This soil generally occurs as large areas.

This soil is generally cultivated, and most areas are well suited to row crops. Frequently flooded or inaccessible areas are commonly in permanent pasture. Poor drainage and a tendency to become cloddy if tilled when wet delay tillage in some years. In many narrow drainageways this soil is dissected by streams that cannot be crossed with farm machinery. Old meandering channels that tend to pond also hinder cultivation in places (fig. 5). In some places flooding causes damage to crops in some years. (Capability unit IIw–1)

Dow Series

The Dow series consists of well-drained soils that formed in calcareous loess under prairie vegetation. Dow soils are on uplands on narrow ridges that are lower than adjacent side slopes. They are also moderately sloping to moderately steep on shoulders of side slopes in the Monona-Ida and Monona-Marshall soil associations. These soils also occur in narrow bands on convex side slopes. In these areas they are mapped in a complex with Monona or Ida soils. Slopes are 5 to 20 percent.

In a representative profile, the surface layer is brown silt loam about 6 inches thick. Below this, to a depth of about 15 inches, is grayish-brown, friable silt loam that contains mottles of strong brown and yellowish brown. Below this is light brownish-gray, very friable silt loam that contains mottles of strong brown and reddish brown.

Dow soils have high available water capacity and are moderately permeable. These soils are moderately alkaline and calcareous throughout. The organic-matter content is low. Available nitrogen and phosphorus are very low, and available potassium is medium. Zinc is deficient in places.

Most areas of these soils are cultivated, but the moderately steep soils are generally used for hay or pasture. Dow soils are subject to sheet and gully erosion.

Representative profile of Dow silt loam, 9 to 14 percent slopes, moderately eroded, on an east-facing

Dow-Ida silt loams, 9 to 14 percent slopes, severely eroded (DoD3). This complex consists of about 50 to 75

Dow-Monona silt loams, 5 to 9 percent slopes, moderately eroded (DwC2).—This complex consists of about 40 to 60 percent Dow soils and 40 to 60 percent Monona soils. The plow layer is generally very dark brown, very dark grayish brown, or dark grayish brown, but a few included severely eroded areas are lighter in color. These soils are in bands on side slopes and on eroded noses at the end of narrow ridges. They are generally downslope from Monona or Ida soils and upslope from Napier soils or areas of Napier-Kennebec-Nodaway silt loams. Most areas are small.

of the Dow soil is very low. Available phosphorus is low and commonly limits the growth of legumes. (Capability unit IVe-2)

Dow-Monona silt loams, 14 to 20 percent slopes, severely eroded (DwE3).—This complex consists of about 60 to 80 percent Dow soils and 20 to 40 percent Monona soils. Most areas are in narrow bands on side slopes. The soils are so eroded that the surface layer typically is only about 3 inches thick and is brown or dark grayish brown. The brown subsoil of the Monona soils and the grayish-brown, calcareous substratum of the Dow soils

C2—17 to 25 inches, yellowish-brown (10YR 5/4) silt loam; massive; some vertical cleavage; very friable; few lime nodules; calcareous; moderately alkaline; gradual, smooth boundary.

C3—25 to 40 inches, yellowish-brown (10YR 5/4 to 5/6) silt loam; brownish yellow (10YR 6/6) when crushed; common, medium, gray mottles and few, fine, strong-

and pasture. Tilth is generally fair, but the surface layer tends to crust after rain. Natural fertility is very low. Available nitrogen and phosphorus are very low and commonly limit crop growth. (Capability unit IIIe-4)

Ida silt loam, 9 to 14 percent slopes, severely eroded (IdD3).—This soil, in most places, has a plow layer that is

These soils occupy low foot slopes that are generally

light silty clay loam. In many places the lower part of the surface layer is very dark grayish brown.

Figure 7.—An area of Judson-Colo-Nodaway complex. This tract consists mainly of Judson and Colo soils; it is in the Marshall association.

Kennebec Series

The Kennebec series consists of moderately well drained, nearly level soils that formed in silty alluvium under prairie vegetation. These soils are on flood plains along streams.

In a representative profile, the surface layer is silt loam about 41 inches thick. The upper part is black, and the lower part is very dark brown. Below this is very dark gray and very dark grayish-brown, friable silt loam that has some dark-brown to yellowish-brown mottles or oxides.

Kennebec soils have very high available water capacity and are moderately permeable. They are typically slightly acid throughout. The organic-matter content is high. Available nitrogen is medium or low, and available phosphorus and potassium are medium.

Most areas of Kennebec soils are cultivated. The soils are subject to flooding and deposition in places.

Representative profile of Kennebec silt loam, on a first bottom, 528 feet south and 62 feet east of the northwest corner of NW¼SW¼ sec. 27, T. 82 N., R. 41 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; cloddy, break-

[illegible]

C1—41 to 54 inches, very dark gray (10YR 3/1) heavy silt loam; very dark grayish brown (10YR 3/2) when crushed; very weak, fine, subangular blocky structure; friable; many fine and medium pores; many large wormholes; some worm casts; many, fine, distinct, dark-brown concretions are visible when soil is rubbed; slightly acid; diffuse, smooth boundary.

C2—54 to 58 inches, very dark grayish-brown (10YR 3/2) heavy silt loam; common, medium, distinct mottles of dark brown and dark yellowish brown and few, fine, faint mottles of gray; structureless; massive; friable; few, soft, dark accumulations of an oxide; slightly acid.

The surface layer is black, very dark brown, or very dark gray. It is as much as 36 inches or more in thickness. The texture is typically silt loam throughout but ranges to light silty clay loam. Overwash, if present, is very dark grayish-brown or dark grayish-brown silt loam 6 to 15 inches thick.

The substratum is black, very dark gray, dark gray, very dark grayish-brown, or dark grayish-brown silt loam. The boundary between the surface layer and substratum is indistinct in many places. Soft, dark, oxide accumulations and mottles of dark brown to yellowish brown, gray, or grayish brown are present at a depth below 36 inches in places.

The Kennebec soils range from slightly acid to neutral throughout.

Kennebec soils are darker in color and lack the distinct stratification that is present in the Nodaway soils. They are

[illegible]

Wetness is generally not a hazard, except in the lowest areas during very rainy periods. Tilth is good. (Capa-

(10YR 6/2) silt coatings on peds when dry; few coarse to fine roots; medium acid; gradual, smooth boundary.

B21t—16 to 22 inches, brown (10YR 4/3) silty clay loam;

Knox silt loam, 14 to 20 percent slopes (KnE).—This soil

but as slope increases, the susceptibility to sheet and layer is about 12 to 18 inches thick. It is on broad, upland divides, generally upslope from other Marshall soils. Included in mapping was one small area of a nearly level Marshall soil on a bench. Also included were a few acres of a somewhat poorly drained soil that has a thicker dark-colored surface layer and grayish-brown colors in the subsoil.

This soil is generally cultivated and is well suited to row crops. Because this soil is nearly level, there is no serious hazard of erosion. Tilth and physical characteristics are good. (Capability unit I–1)

Marshall silty clay loam, 2 to 5 percent slopes (MaB).—This soil has the profile described as representative for the series, except that in many places the surface layer is about 10 to 16 inches thick. Most areas are gently sloping and on broad ridgetops and convex side slopes. About 300 acres of this soil is on high benches along stream valleys; in these areas the underlying material is sand and gravel, and gravel pits are present in places.

Most of the acreage is cultivated. It is susceptible to sheet erosion, but it is well suited to row crops if erosion is controlled. The organic-matter content is generally low or medium. Tilth is fair in most places. (Capability unit IIe–1)

Marshall silty clay loam, 5 to 9 percent slopes (MaC).—This soil has a surface layer of very dark brown to very dark grayish-brown silty clay loam about 7 to 12 inches thick. It is on ridgetops and on convex side slopes. About 200 acres of this soil is on high benches along stream valleys; in these areas the underlying material is sand and gravel, and gravel pits are present in places. Most areas are large.

Most of the acreage is cultivated. It is susceptible to sheet erosion, but it is suited to row crops if erosion is controlled. Tilth is generally good. (Capability unit IIIe–1)

Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded (MaC2).—This soil has a surface layer that, brown occur higher in the profile than in the profile described as representative for the series. It is mostly on straight to convex side slopes. It is generally downslope from other Marshall soils and upslope from the Judson-Colo-Napier complex, which are in drainageways. Most areas are large.

Some areas of this soil are cultivated, but many areas are in permanent pasture because they are associated with steeper soils or are inaccessible to manage efficiently for crops. This soil is susceptible to sheet and gully erosion, but it is suited to row crops if erosion is controlled. It is also well suited to small grains or hay or pasture. Tilth is good in most places. (Capability unit IIIe-2)

Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded (MaD2).—This soil has a surface layer that, in most places, is very dark grayish brown. In places some of the brown subsoil is mixed into the plow layer. In many places mottles of gray to strong brown are higher in the profile than in the profile described as representative for the series. This soil is mostly on straight to convex side slopes. About 70 acres of this soil is on high benches along stream valleys. In these places the underlying material is sand and gravel, and gravel pits are present in places. The soil is generally downslope from other Marshall soils and upslope from Judson soils or the Judson-Colo-Nodaway complex, which are in drainageways. This soil is one of the most extensive in the county.

Most of this soil is cultivated. It is susceptible to sheet and gully erosion, but it is suited to row crops if erosion is controlled. It is also well suited to small grains or hay or pasture. The organic-matter content is generally low. Tilth is fair or poor. (Capability unit

Colo-Nodaway complex, which are in drainageways. About 80 acres of this soil has a surface layer about 7 to 10 inches thick. Some areas have outcrops or narrow bands of Shelby soils between this soil and the drainageways.

Most areas of this soil are used for hay and pasture most of the time. This soil is susceptible to severe sheet and gully erosion, but it is suited to cultivation if erosion is controlled. A crop of corn is commonly grown when stands of grasses or legumes need to be plowed and reseeded. Tilth is generally fair. (Capability unit IVe-1)

Marshall silty clay loam, 14 to 20 percent slopes, severely eroded (MaE3).—In cultivated areas this soil typically has a dark-brown or brown plow layer that is mainly subsoil. In uncultivated areas a very dark grayish-brown surface layer, less than 3 inches thick, overlies the dark-brown or brown subsoil. The subsoil is exposed in many places. Depth to the silt loam substratum tends to be a few inches less than in the representive profile. Gray to strong-brown mottles are also higher in the profile. This soil is mostly on convex sides slopes. It is generally downslope from less sloping Marshall soils and upslope from Shelby soils. In places it is upslope from and adjacent to Judson soils or the Judson-Colo-Nodaway complex, which are in drainageways. Included in mapping were a few small areas where reddish, clayey soils are at the surface. These are shown on the map by a symbol. Most areas are small.

This soil is generally cultivated, but it is not used extensively for row crops because of the eroded surface layer, steepness, and susceptibility to severe sheet and gully erosion. It is better suited to hay and pasture than to row crops. A crop of corn is commonly grown when existing stands of hay or pasture need to be plowed and

Figure 9.—**Profile of Monona silt loam.**

Nearly level to moderately steep Monona soils are mainly cultivated. Steep Monona soils are generally in pasture. All of the soils except for the nearly level Monona soils are susceptible to sheet and gully erosion. The severity of the erosion hazard increases as slope increases.

Representative profile of Monona silt loam, 0 to 2 percent slopes, on a ridgetop that is a distinct watershed divide, 500 feet east and 20 feet north of the southwest corner of sec. 35, T. 84 N., R. 41 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam; cloddy breaking to weak, fine, granular structure; friable; few fine roots; slightly acid; abrupt, smooth boundary.

A3—8 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky and weak, fine, granular structure; friable; many fine and medium pores; few fine roots; some mixing of very dark grayish-brown peds; slightly acid; gradual, smooth boundary.

B1—15 to 21 inches, dark brown (10YR 3/3) silt loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; very dark grayish-brown (10YR 3/2) ped faces; few fine and medium pores; few fine roots; few peds coated with very dark brown stains, probably organic; slightly acid; gradual, smooth boundary.

B2—21 to 29 inches, brown (10YR 4/3) heavy silt loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; dark-brown (10YR 3/3) ped faces; many fine and medium pores; few very fine roots; old root channel fillings of brown (10YR 4/3); some very dark brown (10YR 2/2) coatings on a few peds; neutral; gradual, smooth boundary.

B3—29 to 38 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, fine, subangular blocky structure to massive; friable; abundant very fine and fine pores; few large wormholes; neutral; diffuse, smooth boundary.

C1—38 to 46 inches, dark yellowish-brown (10YR 4/4) silt loam; massive; friable; abundant pores; few wormholes or old root channels; neutral; gradual, smooth boundary.

C2—46 to 48 inches, yellowish-brown (10YR 5/4) silt loam; 30 percent of matrix is olive (5Y 5/3); massive; friable; many fine pores; many, fine, soft oxides; neutral; horizon is distinctly coarser in texture than C1; diffuse, smooth boundary.

C3—48 to 89 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, faint mottles of grayish brown (10YR 5/2) and few, fine, faint mottles of strong brown (7.5YR 5/6); massive; friable; many, fine, soft oxides; neutral.

The surface layer ranges from 10 to 15 inches in thickness in most places unless eroded, but in nearly level areas the thickness is as much as 18 inches. In eroded areas this layer is as thin as 3 inches. It is typically very dark brown or very dark grayish brown except in severely eroded areas where the colors are lighter. It is silt loam or light silty clay loam.

The subsoil, about 12 to 24 inches thick, ranges from brown to yellowish brown. In places very dark grayish-brown colors are in the upper part of the subsoil, generally as coatings on peds. Dark brown is also in the range of color in the upper part of the subsoil. The upper part of the subsoil is silt loam or light silty clay loam.

The substratum is brown to yellowish brown. Mottles range from olive and olive gray to strong brown. The depth to calcareous material varies widely, depending upon the landscape position and the severity of erosion.

Steep soils on convex slopes are calcareous as near the surface as 24 inches. Those Monona soils on benches or nearly level divides are leached to a depth of about 6 feet or more in places. Monona soils range from slightly acid to medium acid in the surface layer and are slightly acid or neutral in the subsoil. The substratum is neutral to moderately alkaline.

The severely eroded Monona soils have a surface layer that is thinner and lighter colored than is defined as the range for the series. These differences do not significantly alter their usefulness or behavior.

The Monona soils are not calcareous at or near the surface, as are Ida soils. They differ from Knox soils in typically having a thicker surface layer, in lacking a grayer subsurface layer, and in varying less widely in clay content between the surface layer and the subsoil. Monona soils have browner colors in the profile than Dow soils and are not calcareous so high in the profile. They differ from Napier soils in having a thinner surface layer. Monona soils have less clay in the surface layer and subsoil and are not so deeply leached as Marshall soils. All the soils, except Napier soils, formed in loess.

Monona silt loam, 0 to 2 percent slopes (MoA).—This soil has the profile described as representative for the series. In places, however, the surface layer is a few inches thicker. Most of this soil is on high benches. Some is on broad, relatively stable ridgetops. Most areas of this soil are large.

Most of this soil is cultivated. It is well suited to row crops. The hazard of erosion is slight. Tilth and physical characteristics are good. (Capability unit I–1)

Monona silt loam, 2 to 5 percent slopes (MoB).—This soil has the profile described as representative for the series, except that the surface layer is a few inches thinner in places. It is mainly on broad, slightly rounded ridgetops. It is generally upslope from moderately sloping or strongly sloping Monona soils.

This soil is generally cultivated. It is susceptible to erosion, but it is well suited to row crops if erosion is controlled. Tilth and physical characteristics are good. (Capability unit IIe–1)

Monona silt loam, 2 to 5 percent slopes, moderately eroded (MoB2).—This soil typically has a very dark grayish-brown plow layer. It is mainly on slightly rounded, narrow ridgetops and generally is upslope from moderately sloping or strongly sloping Monona soils. Included in mapping were a few severely eroded areas where this layer is generally dark brown or brown.

Most of this soil is cultivated. It is susceptible to erosion, but it is well suited to row crops if protected from erosion. Tilth is good in most places. (Capability unit IIe–1)

layer and the low organic-matter content. (Capability unit IIIe–1)

Monona silt loam, 9 to 14 percent slopes (MoD).—This soil typically has a very dark grayish-brown surface layer about 7 to 12 inches thick. The subsoil is typically thinner, and mottles are higher in the profile, than in the profile described as representative for the series. This soil is calcareous at a depth of 30 to 40 inches in many places.

This soil is mainly on side slopes. It is generally downslope from less sloping Monona soils. In many places it is upslope from Napier soils or Napier-Kennebec-Nodaway silt loams. Most areas are small.

Most of this soil is cultivated. It is susceptible to sheet and gully erosion, but it is suited to row crops if protected from erosion. It is also well suited to small grains and hay or pasture. Tilth and physical characteristics are good. (Capability unit IIIe-2)

Monona silt loam, 9 to 14 percent slopes, moderately eroded (MoD2).—This soil typically has a very dark grayish-brown plow layer. Some of the subsoil material is mixed into this layer. The subsoil is typically thinner, and mottles are higher in the profile than in the profile

The soil is calcareous at a depth of 24 to 36 inches in most places. This soil is on side slopes. In some places it is upslope from Shelby soils, and in many places it is upslope from Napier soils or from Napier-Kennebec-Nodaway silt loams. Included in mapping were about 300 acres of a slightly eroded soil that has a very dark brown or very dark grayish-brown surface layer about 7 to 10 inches thick.

This soil is generally cultivated. It is not well suited to row crops, because it is moderately steep and is susceptible to severe sheet and gully erosion. It is generally used for hay and pasture. A row crop is commonly grown when stands of hay or pasture need to be plowed

is exposed in many places. The subsoil is thinner, mottles are higher in the profile, and the soil is not leached so deeply as the soil that has the profile described as representative for the series. The soil is calcareous at a depth of 24 to 36 inches in most places. Included in mapping were about 300 acres of severely eroded Marshall silty clay loam on similar slopes.

This soil is on side slopes. In most places it is upslope from Napier soils or Napier-Kennebec-Nodaway silt loams, but in some places it is upslope from Shelby soils.

This soil is mostly used for permanent pasture. It is not suited to cultivation. It is susceptible to further severe sheet and gully erosion. Gullies are present in places. There is some risk if farm machinery is used on

Representative profile of Napier silt loam, 2 to 5 percent slopes, on a convex fan, 280 feet south and 849 feet east of the northwest corner of sec. 30, T. 84 N., R. 41 W.

A1—0 to 4 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; very friable;

slopes occupied by Monona and Ida soils and on fans at the outlets of upland drainageways.

This soil is generally cultivated. If the associated soils on nearby hillsides are steep, this soil is managed along with those soils as pasture. It is suited to row crops if marily in long, narrow areas along narrow drainageways and minor streams in the Monona-Marshall and Monona-Ida associations. Typical areas have a main stem in the valley and fingers extending up the side-valley drains. Some areas have a waterway that can be crossed with farm machinery. Others have gullies.

Many areas of this complex are cultivated, but the cropping pattern is generally determined by the associated soils. If nearby hillsides are steep and used for pasture, this complex is also used for pasture. Areas that have meandering streams or gullies are generally used for pasture. They are suited to row crops but are susceptible to gully erosion, and lower lying areas are subject to flooding. Tilth and physical characteristics are good. (Capability unit IIIe-6)

Nodaway Series

The Nodaway series consists of moderately well drained, nearly level, stratified soils. These soils formed under prairie vegetation in recently deposited alluvium.

Nodaway soils are on flood plains and are generally near stream channels. They are also in narrow drainageways in a complex with Judson and Colo soils in the Marshall soil association and with Napier and Kennebec soils in the Monona-Ida and Monona-Marshall soil associations.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 9 inches thick. Below this, to a depth of about 48 inches, is stratified, dark grayish-brown, brown, and very dark gray, friable loam to silt loam that contains strata of silty clay loam to silty clay and sandy loam. Below this is very dark gray and brown, friable silt loam.

Nodaway soils have high available water capacity and are moderately permeable. They are typically neutral throughout. Their organic-matter content is low. Available nitrogen is low, available phosphorus is low or me-

The plow layer, or surface layer in unplowed areas, is typically very dark grayish brown, but it is very dark gray or dark grayish brown in some places. The stratified substratum is typically dark grayish brown, but strata range from very dark gray to brown. It is typically silt loam, but thin strata of loam, silty clay loam, sandy loam, or fine sand occur in places. Mottles are present in many places, especially in areas where this soil is in narrow bottom lands that are frequently flooded. Mottles range from strong brown to grayish brown. Buried, dark-colored soils are present at depths greater than 36 inches in places, especially in narrow drainageways and near the heads of drainageways.

Nodaway soils have a thinner surface layer than Kennebec, Napier, Colo, and Judson soils and have distinct stratification that is lacking in those soils. Nodaway soils are not so fine textured as Colo or Judson soils. All of these soils formed in alluvium.

Nodaway silt loam (0 to 2 percent slopes) (No).—This soil is on bottom lands and in most places is adjacent to stream channels.

Most of this soil is cultivated, and row crops are well suited. It is susceptible to flooding and surface deposition, but the flooding generally occurs before crops are planted or is of short duration. Tillage is delayed at times, and crops are sometimes damaged. In most years, however, the damage is slight. Tilth is generally good. (Capability unit I-2)

Salida Series

The Salida series consists of excessively drained soils that formed under prairie vegetation in calcareous, stratified, sandy and gravelly glacial sediments.

Salida soils are on convex side slopes, on the noses of narrow ridges, and on knobs on side slopes. They are also on the tops and sides of narrow ridges. They are mainly on uplands along the Boyer River and near the mouths of larger creeks that flow into the River. Slopes are 9 to 25 percent.

In a representative profile, the surface layer is very dark grayish brown and about 16 inches thick. The up-

A12—8 to 16 inches, very dark grayish-brown (10YR 3/2) gravelly sand; single grain; loose; pebbles as much as 3 inches in diameter; roots concentrated in this horizon; neutral; clear, wavy boundary.

C1—16 to 25 inches, dark yellowish-brown (10YR 4/4) gravelly sand; single grain; loose; less gravel than in A12 horizon; moderately alkaline; calcareous; dif-

Shelby Series

The Shelby series consists of moderately well drained soils that formed under prairie vegetation in glacial till.

Shelby soils are on convex side slopes adjacent to drainageways and major stream valleys. Most areas are crease in size and number in the substratum, especially those of a grayish color.

Shelby soils are typically calcareous at depths between 30 and 60 inches. They range from neutral to medium acid in the surface layer and are slightly acid or medium acid in the subsoil.

Severely eroded Shelby soils have a surface layer that is thinner and lighter colored than is defined as the range for the series. These differences do not significantly alter their usefulness or behavior.

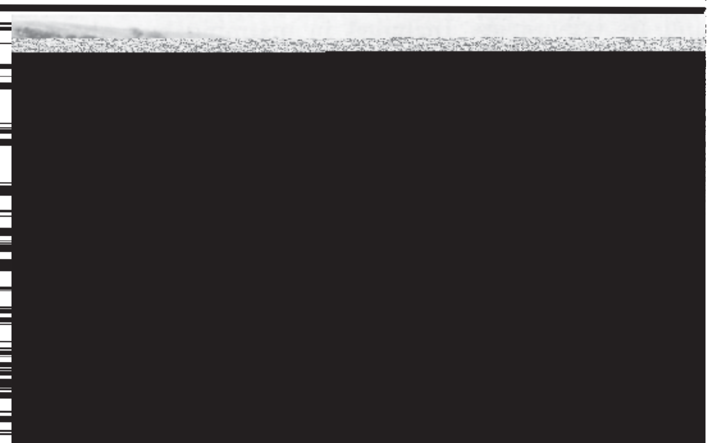
Shelby soils have less clay, lack reddish colors in the subsoil, and do not have so firm a subsoil as Adair soils. They are not calcareous at or near the surface, as are Steinauer soils. Shelby, Adair, and Steinauer soils formed in glacial till.

Shelby loam, 5 to 9 percent slopes, moderately eroded (ShC2).—In most places this soil has a very dark brown or very dark grayish-brown plow layer. In some places it is leached more deeply than the soil that has the profile described as representative for the series. Included in mapping were some severely eroded areas where the surface layer is very thin, and the yellowish-brown or dark yellowish-brown subsoil is exposed in places. This soil is on eroded noses of narrow ridges, at shoulders of slopes, and in other moderately sloping areas. It is gen-

sometimes grown when stands of hay need to be plowed and reseeded or when pastures need renovating. The organic-matter content is typically low, and tilth is fair or poor. (Capability unit IVe-3)

Shelby loam, 18 to 25 percent slopes, moderately eroded (ShF2).—This soil has a dark-brown or very dark grayish-brown surface layer that, in most places, is 3 to 7 inches thick. In most places it is not leached so deeply as Shelby soils on lesser slopes, and in many places the calcareous substratum is at a depth of about 30 inches. It is on side slopes, mainly adjacent to the Boyer River and its tributaries. It is generally downslope from Marshall or Monona soils and is upslope from soils of the drainageways or bottom lands. Included in mapping was about 45 acres of soils that have a grayish-brown subsurface layer and a somewhat more clayey subsoil.

This soil is too steep and too eroded to be cultivated. In most places it is better suited to permanent pasture than to other uses. Most areas are presently used for permanent pasture. In areas that are not too gullied or steep, farm machinery can be used to renovate and reseed pastures. (Capability unit VIe-2)



some areas, but tillage is difficult because of the cobblestones on the surface. Some areas of this soil can be used as wildlife habitat. (Capability unit VIIe-1)

Shelby soils, 9 to 14 percent slopes, severely eroded (SoD3).—These soils typically have a dark-brown or brown, clay loam or loam plow layer. The yellowish-brown subsoil is exposed in many places. The soils are on severely eroded noses of narrow ridges, on the shoulders of slopes, and on side slopes. They are generally downslope from Monona or Marshall soils. They are upslope from soils of the drainageways and bottom lands. Most areas are small.

These soils are generally cultivated and are managed with associated soils that are better suited to cultivation. They are susceptible to sheet and gully erosion, but they are suited to row crops if erosion is controlled. They are better suited to hay or pasture than to row crops. Tilth is poor, and the soils are difficult to till because most of the friable topsoil is gone. These soils crust, and this hinders seedling emergence. (Capability unit IVe-3)

Shelby soils, 14 to 18 percent slopes, severely eroded (SoE3).—These soils typically have a dark-brown or brown surface layer 3 inches or less in thickness. The subsoil is yellowish-brown clay loam or loam; it is exposed in places. These soils are on eroded shoulders of slopes and on side slopes. They are generally downslope from Mo-

places. These soils are not generally leached so deeply as other Shelby soils. They are calcareous in many places at a depth of about 30 inches. Included in mapping were some areas that have a surface layer that is very dark brown or very dark grayish brown and 3 to 10 inches thick. These steep soils are on side slopes, mainly along the Boyer River. Most areas are small.

These soils are not suited to cultivation, because they are steep and severely eroded. They are suited to permanent pasture and to wildlife habitat. Most areas are in permanent pasture. The slope makes renovation of these pastures difficult. (Capability unit VIIe-1)

Sparta Series

The Sparta series consists of excessively drained soils that formed under prairie vegetation in loose, wind-deposited fine sands.

Sparta soils are on crests of ridges and convex side slopes. They are on uplands, mainly near the Boyer River or near the mouths of its major tributaries. In places they are in very small areas surrounded by other soils. Slopes are 5 to 20 percent.

In a representative profile, the surface layer is very dark grayish-brown fine sandy loam about 6 inches

The subsoil ranges from 18 to about 40 inches in thickness and from fine sandy loam to loamy fine sand and fine sand. The fine sandy loam does not extend to a depth greater than 18 inches. It ranges from dark brown to brownish yellow.

The yellowish-brown to very pale brown or yellow sub-

Steinauer Series

The Steinauer series consists of well-drained soils that formed under prairie vegetation in calcareous glacial till.

Steinauer soils are on convex slopes, dominantly on careous at or near the surface, but Shelby soils are typically leached to a depth of 30 inches or more. Steinauer soils are less sandy and gravelly than Salida soils.

fine, subangular blocky and granular; friable; abundant fine and medium roots; abundant wormholes and worm casts; slightly acid; abrupt, smooth

Use and Management of the Soils

Capability Classes, the broadest groups, are designumeral specifically identifies the capability unit within each subclass.

Management by capability units

In the following pages each of the capability units in Crawford County is described, and suggestions for use and management of the soils are briefly discussed. The

medium in available potassium. Organic-matter content is high in the Judson and Kennebec soils, but it is low in the Nodaway soil.

Tilth is good, and these soils are well aerated. Erosion is not a hazard on these soils. The soils are subject to flooding, but the flooding generally occurs before crops are planted or is of short duration. Tillage is delayed

Figure 11.—**An area of Monona soils, which are in capability unit IIe-1. Terraces and grass protect the slopes above the structure from further erosion.**

CAPABILITY UNIT IIe-2

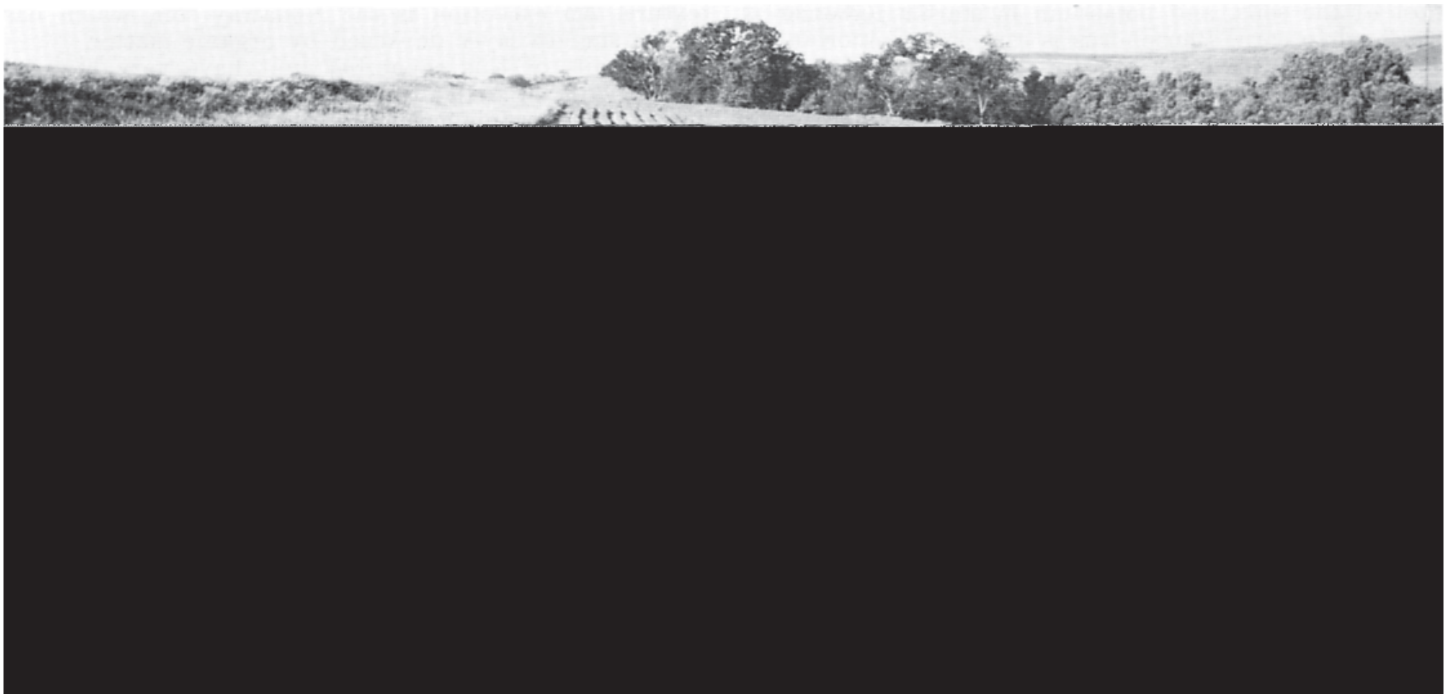
This unit consists of well drained and moderately well drained soils of the Judson and Napier series. Also in this capability unit are the Napier-Kennebec-Nodaway silt loams. All the soils have slopes of 2 to 6 percent and are in narrow upland valleys and on foot slopes. The Judson and Napier soils are in narrow strips, mainly at the foot of slopes occupied by Marshall

retention structures have been used to slow the rate of cutting, to trap sediments, and to prevent further damage (see fig. 11). In many places in soils of this unit, the noncrossable gullies can be shaped and seeded for grassed waterways.

Most areas of these soils are cultivated. Corn and soybeans are the major crops, but oats, alfalfa, and other hay crops are also grown. A few inaccessible areas are

The soils of this capability unit have high or very high available water capacity. Judson and Nodaway

Crops respond well to fertilizer. Nitrogen and phosphorus are likely to be needed. Some potassium in starter



[illegible] Monona silt loam, 9 to 14 percent slopes, moderately eroded. This soil is in capability unit [illegible] most of the soils, and potassium in starter fertilizer is beneficial to corn. Phosphorus is especially important if these soils are used for pasture. Except for some areas of the Monona part of Dow-Monona silt loams, the soils are calcareous and do not need lime. These soils benefit from additions of organic matter in the form of crop residue, barnyard manure, and green manure plowed under. Organic matter improves tilth and the ability of the soils to absorb water.

CAPABILITY UNIT IIIe-5

This unit consists of moderately well drained soils of the Shelby series. These soils have slopes of 5 to 14 percent and are mainly on eroded noses of ridges, on the shoulders of slopes, and on convex side slopes on uplands.

These soils have a surface layer of friable loam and a subsoil of clay loam. The substratum is firm.

The soils in this capability unit have high available water capacity and moderately slow permeability. The organic-matter content is typically low. These soils are typically low in available nitrogen, very low or low in available phosphorus, and low or medium in available

texture. An exception is the Nodaway soil, which has a thin surface layer darkened by organic matter.

The soils of this capability unit have very high or high available water capacity and moderate permeability. The organic-matter content is generally high, but it is low in Nodaway soils. These soils are medium or low in available nitrogen and available phosphorus and medium or high in available potassium.

Tilth is good. These soils are susceptible to sheet and gully erosion and to flooding from streams. They are also subject to runoff from upslope that causes erosion and siltation. Wetness generally is not a hazard, because these soils have enough slope and are permeable enough that water does not stand for long. However, some areas are wet slightly longer than associated soils on uplands. Occasionally, flooding washes out seed or young crops in the area next to the waterway. In places large guillies have formed.

Many areas of these soils are cultivated, but some steeper areas or areas that have meandering streams or gullies are often used for permanent pasture. These soils are suited to row crops much of the time if erosion is controlled. Corn, soybeans, oats, alfalfa, and other

Figure 13.—Grassed backslope terraces on a Monona soil of about 15 percent slope. This soil is in capability unit IVe-1.

crop is grown when the stands of legumes and grasses become poor and need to be plowed and reseeded. Corn is the major row crop; soybeans are seldom grown. Terraces or contour tillage are practices used to control erosion. In some places gullied waterways need to be shaped before terraces are built (fig. 14). Most areas

quate. Phosphorus is especially beneficial if these soils are used for pasture. The soils are typically slightly acid or medium acid in the surface layer, and many areas need lime. These soils, especially those that are severely eroded, benefit from additions of organic matter in the form of crop residue, barnyard manure, or green manure

for hay or pasture most of the time, and a row crop is grown when stands of legumes and grasses become poor and need to be plowed and reseeded. Terraces or contour tillage are practices used to control erosion. In places, gullied waterways need to be shaped before terraces are built.

Crops respond fairly well to fertilizer if moisture is adequate. Nitrogen and phosphorus are very low in most of the soils, and phosphorus is needed if these soils are used for pasture. Only the Monona soils are not calcareous at or near the surface; consequently, lime is needed only in areas of these soils. The soils of this capability unit benefit from additions of organic matter in the form of crop residue, barnyard manure, or green manure plowed under. Organic matter improves tilth and the ability of the soils to absorb and hold water.

CAPABILITY UNIT IVe-3

This unit consists of well drained and moderately well drained soils of the Shelby and Steinauer series. These soils have slopes of 9 to 18 percent and are mainly on side slopes. Most of the soils are severely eroded.

All of these soils have a surface layer of friable or firm loam or clay loam. The subsoil and substratum are [illegible] and are typically firm. The Steinauer soil is

The Sparta soil has a surface layer of fine sandy loam and are loamy fine sand or fine sand below. The Salida soil has a surface layer of gravelly loam and is typically gravelly sand below.

The soils in this capability unit have very low available water capacity and rapid or very rapid permeability. The organic-matter content is low. The soils are very low or low in available nitrogen, very low in available phosphorus, and low or medium in available potassium.

The Sparta soil is easy to till, but the Salida soil is difficult to till because it is so gravelly. These soils are droughty and are susceptible to erosion. Soil blowing is a hazard on the Sparta soil, and at times blowing sand injures young plants.

These soils are not well suited to cultivated crops, because they are droughty. Some areas surrounded by better soils are cultivated. They are better suited to hay and pasture than to row crops. If row crops are grown, they should be on the contour. Mulch tillage helps to control erosion and soil blowing on the Sparta soil and helps to prevent damage to young crops. Terraces are seldom built because of the difficulties in construction and maintenance and because these soils are so permeable that the amount of runoff is small. Some areas managed as timber, they should be protected from grazing. These areas can be used for recreation and as wildlife habitat.

Addition of fertilizer is generally beneficial in areas used for pasture. Phosphorus is needed, and if the stand of legumes is thin or lacking, nitrogen is also generally needed. The Ida soil does not need lime, but the other soils need lime in places.

CAPABILITY UNIT VIe-2

This unit consists of well-drained to somewhat poorly drained soils of the Adair, Shelby, and Steinauer series.

ability. The natural fertility and organic-matter content are low.

These soils are very droughty. They are susceptible to some soil blowing, and in places blowing sand injures young plants on these and surrounding soils. They absorb rainfall readily, but they are susceptible to some sheet erosion and gullying. They dry out quickly and can be worked soon after rains. They warm up quickly in spring.

Many areas of these soils are small, and they generally are managed as cropland along with soils that are better suited to cultivation. Other areas are in hay or pasture.

in managing pasture on these soils. Overgrazing results in lower production of forage and increased sheet erosion and gullying. Timbered areas to be managed as woodland should not be grazed. These soils can be used for recreation or wildlife habitat.

CAPABILITY UNIT VIIs-1

This unit consists of soils of the Chute, Salida, and Sparta series. These soils have slopes of 12 to 25 percent and are on uplands.

The Chute and Sparta soils have a surface layer of fine sandy loam and are loamy fine sand or fine sand below. The Salida soil has a thin surface layer of gravelly loam and is typically gravelly sand below.

The soils of this capability unit have very low available water capacity and rapid or very rapid permeability. The organic-matter content is very low.

These soils are very droughty. Because much of the rain infiltrates fairly rapidly, runoff is not great, but

above average. Large amounts are not feasible. Control of grazing is important to maintain a vegetative cover and to control erosion. These soils can be used for recreation areas or wildlife habitat.

Predicted yields

In table 2 the average yields per acre of the principal crops are predicted for soils of the county under a high level of management. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of suitable varieties; erosion is controlled; the organic-matter content and tilth are maintained; the level of fertility for each crop is maintained, as indicated by soil tests and field trials; the water level in wet soils is controlled; excellent weed and pest control are provided; and operations are timely.

Many available sources of information were used to make these estimates, including data from the federal

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*—Continued

Soil	Corn	Soybeans	Oats	Alfalfa-bromegrass hay	Bromegrass pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*A.U.D.*[1]
Knox silt loam, 5 to 14 percent slopes	84	32	59	3.2	151
Knox silt loam, 14 to 20 percent slopes				2.6	124
Knox silt loam, 20 to 30 percent slopes					[2] 70
Marshall silty clay loam, 0 to 2 percent slopes	103	39	72	3.9	185
Marshall silty clay loam, 2 to 5 percent slopes	101	38	71	3.8	182
Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	98	37	69	3.7	176
Marshall silty clay loam, 5 to 9 percent slopes	96	36	67	3.6	173
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	93	35	65	3.5	167
Marshall silty clay loam, 9 to 14 percent slopes	87	33	61	3.3	157
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	84	32	59	3.2	151
Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	78	30	55	3.0	140
Marshall silty clay loam, 14 to 20 percent slopes, moderately eroded	69		48	2.6	124
Marshall silty clay loam, 14 to 20 percent slopes, severely eroded	63		44	2.4	113
Monona silt loam, 0 to 2 percent slopes	100	38	70	3.8	180
Monona silt loam, 2 to 5 percent slopes	98	37	69	3.7	176
Monona silt loam, 2 to 5 percent slopes, moderately eroded	95	36	67	3.6	171

important in selecting sites for ponds for fish and in maintaining aquatic or semiaquatic habitat for waterfowl or some species of furbearing animals.

trails for horseback riding, nature study, picnicking, and camping.

Many areas that cannot be used economically to pro-

3. Make preliminary evaluations of soil and ground conditions that aid in selecting highway and air-

grained (six classes), or highly organic (one class). An approximate classification can be made in the field. The

Soil features affecting highway work [3]

Many of the soils in Crawford County formed in loess

intercepted by subdrains in places to improve slope stability. In these areas, the in-place density of the loess is relatively low, and the soil has a high moisture content.

Below the clay layer, outcropping on lower slopes, is Kansan till that is heterogeneous but primarily an A–6 or A–7 (CL) soil. The Shelby and Steinauer soils formed in the till. Where this soil is along grading projects, it is normally placed in the upper subgrade through unstable areas. Pockets and lenses of sand and gravel are commonly interspersed throughout the till, and many are water bearing. Where the road grade is only a few feet above such a deposit, and loess or silty till is over it, frost heaving is likely to develop unless the deposit is drained or the soil above it is replaced with granular backfill or a good clay till.

The bedrock in Crawford County is so deeply buried

and embankments more than 15 feet in height should be carefully analyzed to be sure there is sufficient strength in the thick foundation soils to support them. Roadway embankments through bottom lands should be constructed on a continuous embankment that extends above the level reached by frequent floods. In places the Nodaway soils have lenses of fine sand, and if an embankment is constructed only a few feet above the water table in these soils, frost heaving results unless proper drainage is established or materials not susceptible to frost action are used in the subgrade.

Ratings are given in table 4 to show the suitability of

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture	Classification: Unified
	Feet	*Inches*		
Kennebec:[3] Kb, Kc	3-5	0-41	Silt loam	OL or CL or ML-CL
		41-58	Silt loam	CL
Knox: KnD, KnE, KnF	>5	0-16	Silt loam	ML-CL or CL
		16-52	Silty clay loam	ML-CL or CL
		52-60	Silt loam	ML-CL or CL
Marshall: MaA, MaB, MaB2, MaC, MaC2, MaD, MaD2, MaD3, MaE2, MaE3.	>5	0-20	Silty clay loam	ML-CL or CL
		20-37	Silty clay loam	ML-CL or CL
		37-94	Silt loam	ML-CL or CL
Monona: MoA, MoB, MoB2, MoC, MoC2, MoC3, MoD, MoD2, MoD3, MoE2, MoE3, MoF2, MoF3, MoG3.	>5	0-21	Silt loam	ML-CL or CL
		21-89	Silt loam	ML-CL or CL
*Napier: NbB, NbC, NbD, NgC, NkB, NkC. For Kennebec and Nodaway parts of NkB and NkC, see Kennebec and Nodaway series.	>5	0-31	Silt loam	OL or CL
		31-56	Silt loam	ML-CL or CL
Nodaway:[3] No	3-5	0-70	Silt loam and loam to silt loam	ML-CL or CL
Salida: SaD2, SaF2	>5	0-8	Gravelly loam	SM-SC or SM
		8-50	Gravelly sand	SP-SM or SM
Shelby: ShC2, ShD2, ShE2, ShF2,[4] SlF, SoD3, SoE3, SoF3, SoG3.	>5	0-13	Loam or clay loam	CL
		13-60	Clay loam	CL
Sparta: SpC2, SpD2, SpE2	>5	0-14	Fine sandy loam and loamy fine sand.	SM
		14-70	Fine sand	SM or SP-SM
Steinauer: SrD3, SrE3	>5	0-70	Clay loam	CL
Zook:[3]				
Zo	1-3	0-12	Silty clay loam	OH or CH
		12-70	Silty clay	CH
Zs	1-3	0-12	Silt loam	ML-CL or CL
		12-24	Silty clay loam	OH or CH
		24-70	Silty clay	CH

[1] Available water capacity ranges from 0.02 of an inch below to 0.02 of an inch above the figure shown in this column.

significant in engineering—Continued

Classification—Con.	Percentage passing sieve—			Permeability	Available water capacity [1]	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(8-12) or A-7-6(10-14)	----------	100	90-100	0. 63-2. 0	. 22	6. 1-6. 5	Moderate.
A-6(8-12) or A-7-6(10-14)	----------	100	90-100	0. 63-2. 0	. 19	6. 1-6. 5	Moderate.
A-6(10-13)	100	100	95-100	0. 63-2. 0	. 21	5. 6-6. 0	Moderate.
A-7-6(12-16)	100	100	95-100	0. 63-2. 0	. 19	5. 6-6. 5	Moderate.
A-6(10-13)	100	100	95-100	0. 63-2. 0	. 18	6. 1-6. 5	Moderate.
A-7-6(10-14)	----------	100	95-100	0. 63-2. 0	. 21	6. 1-6. 5	Moderate.
A-7-6(12-18)	----------	100	95-100	0. 63-2. 0	. 19	6. 1-6. 5	Moderate or high.
A-7-6(10-14)	----------	100	95-100	0. 63-2. 0	. 18	6. 1-7. 3	Moderate.
A-7-6(10-14)	----------	100	95-100	0. 63-2. 0	. 21	6. 1-6. 5	Moderate.
A-6(8-12) or A-7-6(10-14)	----------	100	95-100	0. 63-2. 0	. 19	6. 6-7. 3	Moderate.
A-6(8-12) or A-7-6(10-13)	----------	100	95-100	0. 63-2. 0	. 23	5. 6-7. 3	Moderate.
A-6(8-12) or A-7-6(10-13)	----------	100	95-100	0. 63-2. 0	. 21	6. 6-7. 3	Moderate.
A-6(6-10) or A-7-6(10-12)	100	100	90-100	0. 63-2. 0	. 19	6. 6-7. 3	Moderate.
A-2-4(0)	80-90	70-80	20-30	2. 0-6. 3	. 10	6. 1-6. 5	Low.
A-2-4(0) or A-1-b(0)	75-90	50-70	5-20	>20. 0	. 03	7. 4-8. 4	Very low.
A-6(8-14)	85-95	80-90	50-65	0. 2-0. 63	. 18	6. 1-6. 5	Moderate.
A-6(8-14) or A-7-6(12-16)	85-95	80-90	50-65	0. 2-0. 63	. 16	6. 1-7. 8	Moderate.
A-2-4(0) or A-4(0-2)	100	100	20-40	6. 3-20. 0	. 08	5. 6-6. 0	Low.
A-2-4(0) or A-3(0)	100	100	8-20	6. 3-20. 0	. 04	6. 6-8. 4	Low.
A-6(8-14) or A-7-6(12-16)	90-100	80-95	55-75	0. 2-0. 63	. 16	7. 9-8. 4	Moderate.
A-7-6(16-20) or A-7-5(16-20)	----------	100	90-100	0. 06-0. 20	. 19	6. 1-6. 5	High.
A-7-6(16-20)	----------	100	90-100	0. 06-0. 20	. 17	6. 1-6. 5	High.
A-4(8) to A-6(10)	100	95-100	90-100	0. 63-2. 0	. 19	6. 6-7. 3	Moderate.
A-7-6(16-20) or A-7-5(16-20)	----------	100	90-100	0. 06-0. 20	. 19	6. 1-6. 5	High.
A-7-6(16-20)	----------	100	90-100	0. 06-0. 20	. 17	6. 1-6. 5	High.

4 The Shelby cobbly loam soil contains variable amounts, but generally many more cobblestones and stones in the surface layer and through-

TABLE 4.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Adair: AdD3, AdE3	Poor: generally low organic-matter content.	Not suitable	Not suitable	Very poor: subsoil is highly elastic and has high shrink-swell potential; substratum compacts readily to high density.	Strongly sloping and moderately steep; seepage can be expected in cuts.	Slight compressibility; seepy and wet in places; high shrink-swell potential.
Chute: ChD3, ChE3	Poor: thin layer of suitable material; low fertility and organic-matter content.	Fair: poorly graded; fine grained.	Not suitable; lacks gravel.	Good: slight compressibility; low shrink-swell potential; slopes are erodible unless dressed with top-	Moderately sloping to moderately steep; erodible; loose sand can hinder excavation; difficult to	Fairly good bearing capacity and shear strength; slight compressibility; low shrink-swell po-

interpretations

properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Soil features affecting—Continued						Degree of limitation for—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment						
Very slow permeability if compacted; easily compacted.	Fair or good stability; impervious when compacted; high shrink-swell potential in subsoil, moderate below; good for impervious cores.	Seasonally wet because of seepage; tile placed upslope helps to reduce wetness by intercepting runoff.	High available water capacity; slow permeability; strongly sloping or moderately steep.	Subsoil unfavorable for crops and difficult to vegetate; terrace channels likely to be seepy and wet.	Seepy and wet; subsoil unfavorable for crops; difficult to vegetate.	Severe where slopes are more than 9 percent; slow permeability.	Severe where slopes are more than 9 percent.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Very low available [illegible]	Moderate where [illegible]	Severe: rapid or [illegible]

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]

interpretations—Continued

Soil features affecting—Continued						Degree of limitation for—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment						
Generally no sites suitable for farm ponds; high organic-matter content; uncompacted material has moderate permeability.	High in organic-matter content; difficult to compact; high compressibility.	Most areas do not need drainage; subject to flooding; moderate permeability.	High available water capacity; medium intake rate; subject to flooding.	Terraces not needed; soil features favorable for diversions.	Generally not needed; soil features favorable.	Moderate or severe: moderately permeable; subject to flooding; high water table in places.	Moderate or severe: subject to flooding; high in organic-matter content; moderate permeability.
Uncompacted	Fair stability; fair	Not needed; well	High available	Soil features	Soil features	Moderate where	Moderate where

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings[1]
Salida: SaD2, SaF2	Very poor: gravelly; low fertility	Fair to good: fairly well graded mix-	Fair to good: fairly well graded mix-	Good: good bearing capacity; low shrink-swell	Undulating; good source of subgrade material	Good bearing capacity and shear strength; l-

interpretations—Continued

Soil features affecting—Continued						Degree of limitation for—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment						
Substratum too porous to prevent excessive seepage.	Good stability; good compaction; slight compressibility; somewhat pervious; fair to poor resistance to piping; stones and boulders in places.	Not needed; excessively drained.	Rapid water intake rate; very low available water capacity; sloping; poor farming potential.	Shallow to sand and gravel; erodible and difficult to vegetate.	Shallow to sand and gravel; difficult to vegetate.	Severe: slope; very rapid permeability; danger of pollution.	Severe: very rapid permeability.
Uncompacted material has moderately slow permeability; suitable sites likely for farm ponds.	Fair or good stability; good workability and compaction characteristics; suitable for cores.	Generally not needed; moderately well drained; seepy areas in places.	High available water capacity; moderately sloping to steep; subject to runoff and erosion.	Soil features favorable for construction, except for stones and boulders; subsoil is firm and low in fertility.	Soil features favorable for construction, except for stones and boulders; subsoil is firm and low in fertility.	Severe: slope; moderately slow permeability.	Moderate where slopes are less than 9 percent; severe where slopes are more than 9 percent; moderately slow permeability.
Rapid or very rapid permeability; too porous to hold water.	Pervious when compacted; poor resistance to piping; erodible; low shrink-swell potential.	Not needed; excessively drained.	Very low available water capacity; erodible; very rapid intake rate.	Erodible; difficult to maintain and and vegetate.	Erodible; difficult to vegetate; very low available water capacity.	Moderate where slopes are 5 to 9 percent; severe where slopes are more than 9 percent; rapid or very rapid permeability; risk of pollution.	Severe: rapid or very rapid permeability.
Uncompacted material has moderately slow permeability; pockets of sand and gravel in places.	Fair or good stability; good workability and compaction characteristics; suitable for cores.	Not needed; well drained.	High available water capacity; strongly sloping and moderately steep; subject to runoff and erosion.	Irregular short slopes; soil features generally favorable for construction but some stones; low fertility; difficult to vegetate.	Erodible; difficult to vegetate.	Severe: slope; moderately slow permeability.	Severe: slopes more than 9 percent; moderately slow permeability.
Soil features favorable; generally no sites suitable for farm ponds.	Fair stability; high shrink-swell potential; high organic-matter content.	Seasonal high water table; slowly permeable.	High available water capacity; slowly permeable.	Not needed; nearly level bottom land.	Not needed in most areas; seasonal high water table and wetness.	Severe: slowly permeable; seasonal high water table.	Moderate or severe depending on degree of flooding; high in organic-matter content; slow permeability.

Formation and Classification of the Soils

This section consists of three main parts. In the first

plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent

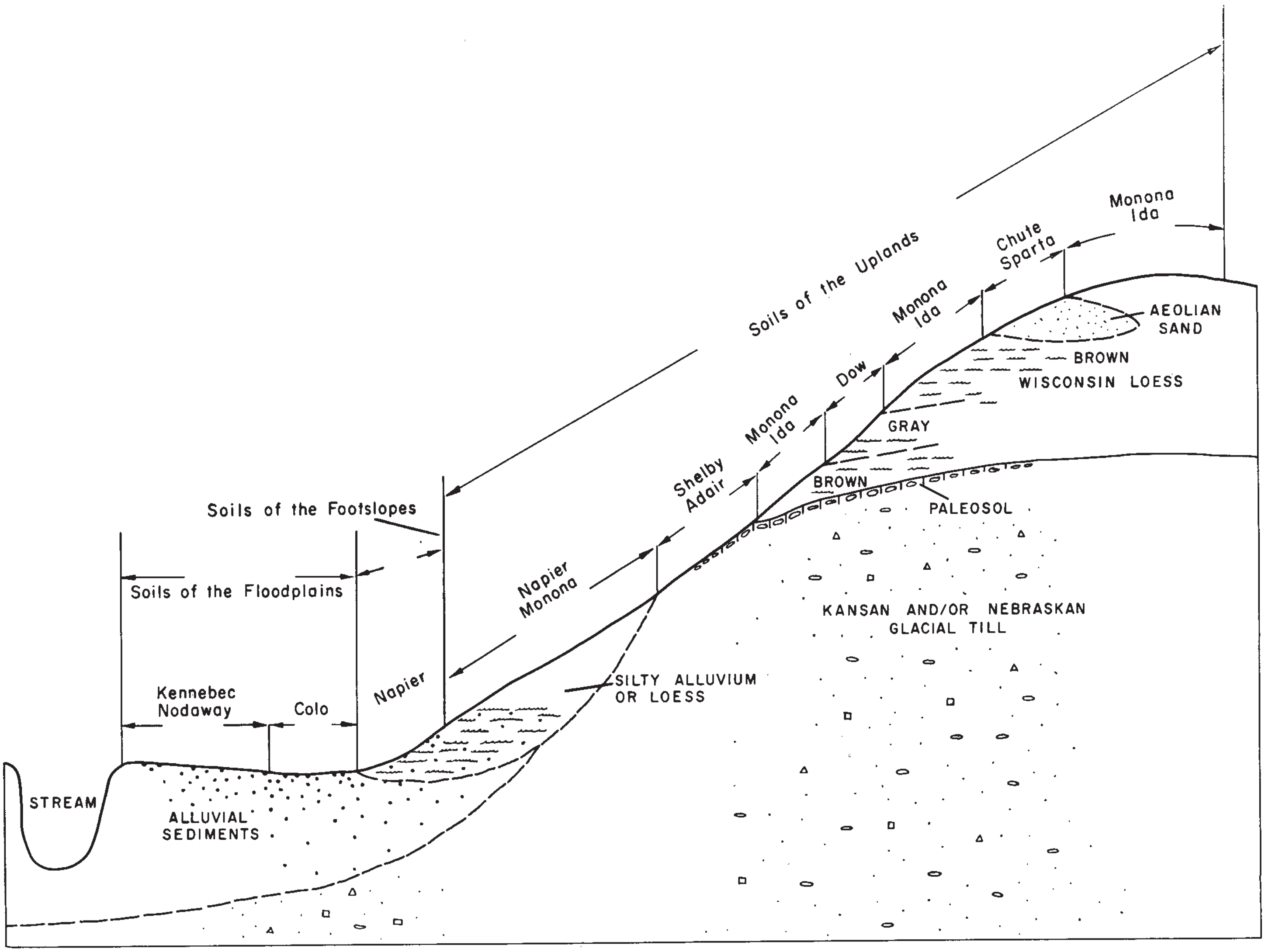


***Figure 17.*—Relationship of parent material to the soils in the western part of Crawford County.**

Most of the upland is occupied by soils that formed in loess. The most extensive soils are those of the Monona, Ida, and Marshall series. Also formed in loess were soils of the Knox and Dow series. Dow series formed in deoxidized and unleached, grayish loess.

The loess is thickest in the western part of the county in the Monona-Ida association. Here the loess is as thick as about 55 feet on the most stable parts of the landscape. The loess thins out in a northeasterly direction and is about 15 to 20 feet thick on stable divides in the northeastern Crawford County are on hillsides along the Boyer River valley and its main tributaries where the loess has been removed by erosion. The acreage occupied by soils derived from glacial till is small.

Crawford County has been subjected to two major glaciations, namely the Nebraskan and the Kansan (*27*). The Nebraskan till is the older and is overlain by the younger Kansan till, which is generally the one that is exposed. The unweathered till is firm, calcareous clay loam. It contains pebbles, boulders, and sand, as well as called "gumbotil" (*8*, *9*). The gumbotil is several feet thick and is very slowly permeable. It formed during

part of the county. Sandy sediments in the stream valleys were probably the source of these sands. They were

Soils formed under prairie vegetation typically have a thicker, darker colored surface layer than soils formed under trees, because grasses have many roots and tops that have decayed or are in the soil. Under trees, the organic matter, derived principally from leaves, was deposited mainly on the surface of the soil. Soils that formed under trees generally are more acid than those formed under grass. Marshall and Monona soils are typical of those soils that formed under prairie vegetation. Soils, such as Knox soils, however, have properties that

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Very similar kinds of soils form from widely different kinds of parent material if other factors continue to be active over long periods of time. But soil formation is generally interrupted by geologic events that expose new parent material.

New parent material has been added to the upland at least three times (21). The bedrock has been covered by taneously in soils, and the ultimate nature of the profile is governed by the balance of these changes within the profile.

Addition of organic matter is an early step in the process of horizon differentiation in most soils. In some soils in Crawford County the darkened surface layer is the only soil feature that reflects to any degree the basic processes mentioned above. The Ida and Steinauer soils formed in similar calcareous parent materials. For example, Ida soils, which are calcareous, are very low in available phosphorus. In Monona soils, which have been leached and are about neutral, the available phosphorus, although low, is in better supply than in Ida soils.

Classification of the Soils

Table 5.—*Classification of soil series by higher categories*

Series	Family	Subgroup	Order
Adair [1]	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Chute	Mixed, mesic	Typic Udipsamments	Entisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Entisols.
Dow	Fine-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Ida	Fine-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Knox	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Marshall [1]	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Monona [1]	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Napier	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Shelby [1]	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sparta [1]	Sandy, mixed, mesic	Entic Hapludolls	Mollisols.
Steinauer	Fine-loamy, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Zook	Fine, montmorillonitic, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols.

[1] In this county these soils are taxadjuncts to the series for which they are named because of the following characteristics: Adair soils [illegible] and Shelby soils have a surface horizon that is thinner or lighter colored, or both, than [illegible]

rain falls mostly during the warm part of the year when the ground is unfrozen and has been tilled. The hazard of erosion, most severe in the western townships, reaches maximum late in the spring and early in summer. Heavy showers are most frequent in May and June, before most crops establish adequate ground cover and root systems. Because most showers cover only a few miles, rainfall variations are generally very marked, even though seasonal totals tend to obscure the variations. About 10 percent of the annual precipitation falls as snow. Snowfall averages about 25 inches a year and falls mainly from November through March.

At crop planting time there is preferably ample subsoil moisture and the surface layers are relatively dry. Well-spaced, gentle showers thereafter throughout the growing season are desirable. Variations from the desired pattern

transpiration on these days generally causes plant stress that limits growth and development.

Tables 6 and 7 give temperature and precipitation data recorded at Denison.

Farming

This section discusses farming in Crawford County. Unless otherwise stated, the data given are from the 1967 Iowa Annual Farm Census, published by the Iowa Department of Agriculture, Division of Agricultural Statistics.

Farming is the main enterprise in Crawford County. The farming is diversified and includes crop production and livestock raising. About 97 percent of the county, or 446,753 acres, is in farms. The average size of the

TABLE 7.—*Probabilities of freezing temperatures in spring and fall*

[All data from Denison, elevation 1,401 feet, based on records for the period 1931–60]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring					
1 year in 10 later than	April 8	April 14	April 24	May 9	May 17
2 years in 10 later than	April 3	April 9	April 20	May 4	May 12
5 years in 10 later than	March 25	March 31	April 11	April 24	May 3
Fall:					
1 year in 10 earlier than	October 23	October 18	October 9	October 3	September 22
2 years in 10 earlier than	October 29	October 23	October 15	October 8	September 26
5 years in 10 earlier than	November 8	November 2	October 25	October 17	October 4

The yields of crops have been steadily increasing because of the use of more fertilizer and lime, more productive facilities, better erosion control, and improved management. The acreage of crops in Crawford County in 1967 was as follows: Corn, 148,312; oats, 33,400; soybeans, 37,932; popcorn, 6,284; all hay, 46,556; and all pasture, 108,742.

The feeding of beef cattle and hogs is the most important livestock enterprise. Many of the beef cattle are bought out of the State and trucked into the county for feeding. Hogs are mostly farrowed and fed on the same farm, but some feeder pigs are brought in. The beef cattle and hogs are marketed at the packing plants in Denison and at other marketing centers, including Omaha and Sioux City.

The numbers of beef cattle, hogs, and lambs fed in the county are increasing. Dairy cows and heifers on hand are decreasing, but beef cows and heifers on hand are increasing. The production of chickens has decreased; turkey production has been variable, but the general

into all parts. Eventually, all of the drainage goes into the Missouri River. The Boyer River and its tributaries are the primary drainage system that extends from the northeastern to the southwestern part of the county. Some of the larger tributaries of the Boyer River are Buffalo, Otter, Tucker, Trinkle, and Beaman Creeks. Soldier, Middle Soldier, and East Soldier Rivers and Beaver Creek are the principal streams in the northwestern part of the county. Willow, Middle Willow, and South Willow Creeks drain the southwestern part of the county and flow generally parallel to the Boyer River. The Nishnabotna River and its tributaries drain the southeastern part of the county. The channels of the Boyer, Soldier, and Nishnabotna Rivers have been straightened and enlarged, which largely eliminates damage from floods. In some places artificial drainage channels have been constructed at the junction of the creeks with the major stream to reduce flooding.

The soils on uplands in the county are mainly well drained. Colo and Zook soils in the bottom lands are

(8) Kay, George F.
1916. GUMBOTIL, A NEW TERM IN PLEISTOCENE GEOLOGY. Science (new series) 44: 637–638.

(9) ——— and Apfel, Earl T.
1929. THE PRE-ILLINOIAN PLEISTOCENE GEOLOGY OF IOWA.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath

called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Second bottom. The first terrace above the normal flood plain of a stream.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

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